The link between travel Time Budget and Speed: a Key relationship for urban space-time dynamics

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European Transport Conference 2004

Palais de la Musique et des Congrès,
Strasbourg, France

THE LINK BETWEEN TRAVEL TIME BUDGET AND SPEED: A KEY RELATIONSHIP FOR URBAN SPACE-TIME DYNAMICS

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ABSTRACT

The relationship between travel time budget (TTB) and speed is central to transport economics and allows us to analyze travel behaviour, urban structure and the transport system. Together, this relationship and Zahavi's hypothesis provide a straightforward mechanism that explains the increase in daily travel distances and urban sprawl. However, quantitative analysis (Regression Analysis and Principal Component Analysis) shows that TTBs are only stable at an aggregate level, and the potential of urban speed restriction policies is severely limited at local level.

INTRODUCTION

Increasing car ownership has increased accessibility as measured by the space-time prism (Hägerstrand, 1970) for a large proportion of the urban population. Individuals have modified their exploitation of the city's opportunities to take advantage of these new accessibilities. Observation of recent decades reveals that the new activity patterns have led to an increase in daily travel distance, but Travel Time Budgets (TTB) seem to have remained relatively stable. Hence, travel behaviour has been to some extent modified by the new organization of the urban system.
In the long term, urban structure is modified and re-organized around the new interaction spaces and transport opportunities generated by the new travel behaviours. The new accessible opportunities are producing new locational choices.
The paper aims to shed light on this co-production relationship between land-use and transport. This dynamics must be studied with regard to the three interacting dimensions of travel behaviour, urban structure and the transport system. To investigate this co-production relationship we shall use the TTB-speed relationship to examine the three interacting dimensions.
The first part of the paper will consist of a discussion of the place of TTB in travel analysis. TTB has often been used as a key variable for understanding

travel behaviour. It introduces an additional constraint on individual transport choices. In spite of the fact that one could expect a trade-off between monetary and temporal resources, TTBs seem to have remained stable since the 1950s. This stability constitutes Zahavi's hypothesis, which states that TTBs remain stable in different places and at different times. Then, after a survey of research which accepts this stability, we shall discuss the relationship between TTB and speed and the way this relationship shapes urban structure. When associated with urban travel speed, the TTB provides a spatial dimension that can be used to analyze the interrelationship between transport and urban structure. Speed thus allows us to see how the TTB imposes a structure on travel choices, land-use and transport supply.

The relationship between TTB and speed will permit us to explore the formation of urban structure and then question urban and transport policies, which are challenged by Zahavi's hypothesis. Under the hypothesis of TTB stability, travel time savings are totally reinvested in transport. This reinvestment mechanism could explain urban sprawl, making increased speed completely responsible for the problems which are caused by and which affect urban transport.

The third part of the paper will examine TTB levels. The UITP database contains aggregate travel data for 100 cities for 1995 and gives us the opportunity to test the hypothesis of TTB stability. Our analysis supports Zahavi's hypothesis at a world-wide aggregate level, but it reveals two contrasting urban organizations with distinct TTB dynamics. This opposition is based on contrasts that relate to space, time and speed.

Finally, the issue of the existence of stability at continental level will be examined and Regression Analyses and Principal Component Analyses (PCA) of TTBs will be performed. These quantitative tools reveal the variables that are linked to TTB. Some effects apply to all cities and may be used to direct transport policy, but there are some effects which are specific to each urban model.

I. ZAHAVI'S HYPOTHESIS

A. From convergence to stability

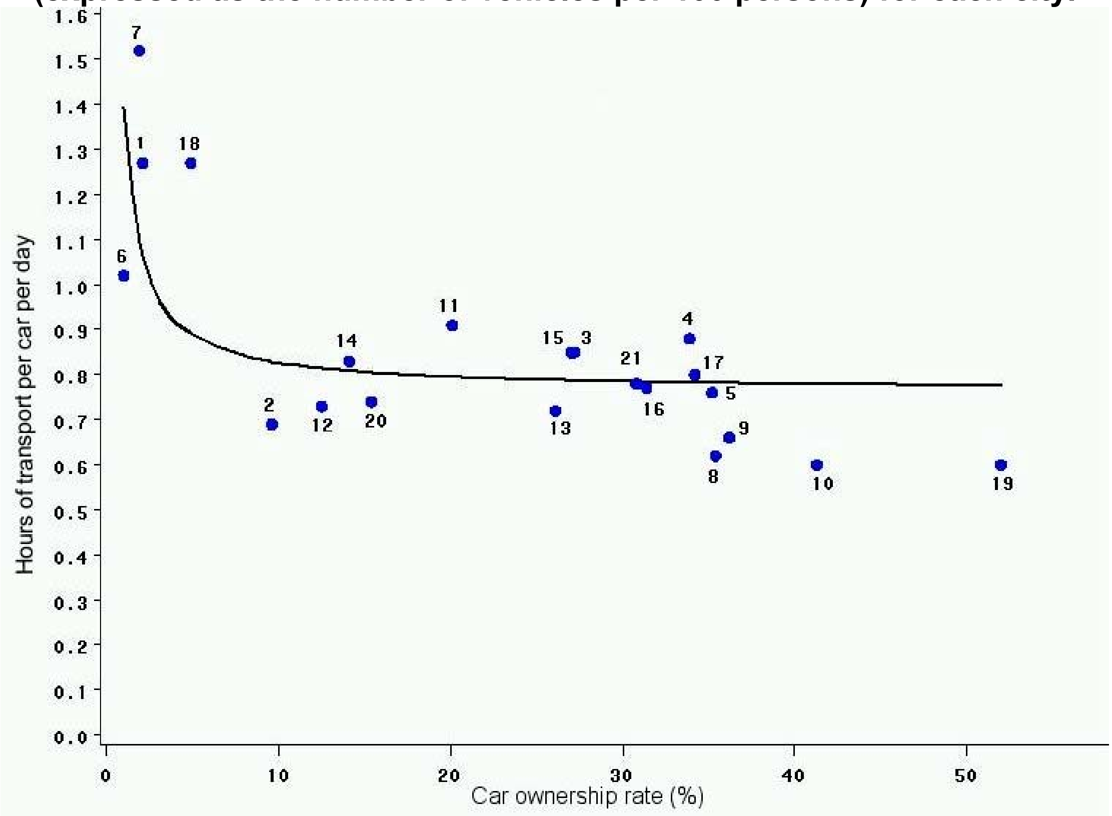
Zahavi's hypothesis has been defined at two different levels. First, it states that at an aggregate (world-wide) level, the mean TTBs for cities at different times are similar. Second, at the disaggregate (local) level, travel expenditures exhibit regularities that are assumed to be transferable in different cities and at different times.

Zahavi (1974, 1973) has shown that TTB and TMB (Travel Money Budget) are linked to the socio-economic characteristics of individuals, the characteristics of transport supply and urban structure. Furthermore, the stable forms of these relationships in different cities leads to their inclusion in a travel demand forecasting model. These regularities mean that an individual's travel expenditure can be considered as a budget whose amount is rationally determined. Zahavi was one of the first scholars to suggest the expenditure

budgets concept and to incorporate time budgets in the optimisation program for individual travel choices[1].
Both TTB and TMB appear as constraints in Zahavi's model, which he named the "Unified Mechanism of Transport" (UMOT, 1979). Zahavi reduces the problem of the allocation of resources to transportation to the simple problem of the distribution of fixed amounts of temporal and monetary resources between the different modes of transport.

First, Zahavi determined the TTB as an inverse function of mean travel speed. On the basis of a number of studies, Zahavi reconstructed the data set which contains the observed and predicted TTB in various cities and countries. This investigation of the TTB of such a large variety of cities[2] prompted Zahavi to formulate the idea that TTB is convergent with travel speeds.

***Graph 1* – Hours per day of travel per vehicle and car ownership (expressed as the number of vehicles per 100 persons) for each city.**



N°	City	Year	N°	City	Year
1	Athens	1962	12	Kingston Upon Hull	1967
2	Athens	1980	13	Kingston Upon Hull	1981
3	Baltimore	1962	14	London	1962
4	Baltimore	1980	15	London	1981
5	Bâton Rouge	1965	16	Meridian	1967
6	Bombay	1962	17	Pulaski	1964
7	Bombay	1981	18	Tel-Aviv	1965
8	Brisbane	1981	19	Tucson	1980
9	Chicago	1980	20	West Midlands	1964
10	Columbia	1985	21	West Midlands	1981
11	Copenhagen	1967			

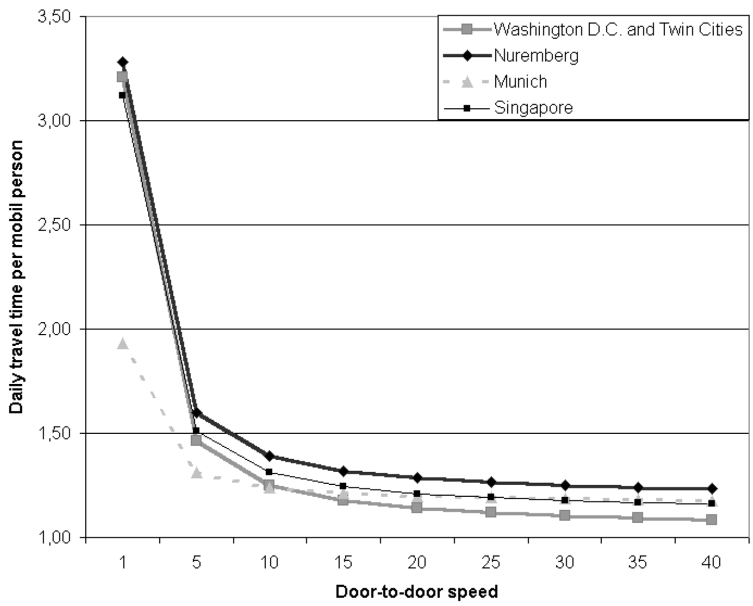
Source: Y. ZAHAVI (1973)

Zahavi revealed the existence of a critical car ownership rate for the population beyond which the daily duration of travel per vehicle tends to converge. On the basis of a large number of formalizations and tests of this convergence, Zahavi proposed a direct relationship between TTB and travel speed which achieves convergence very rapidly. He described the relationship between travel speed and average TTB with the following function:

$$TTB = b + \frac{a}{speed}$$

where *a* and *b* are coefficients to be determined: *b* is the level of convergence of the TTB, it is estimated to be slightly under one hour of travel.
For the estimates that had been made on the basis of different samples (Graph 2), Zahavi obtained very rapid convergence of average TTB at around one hour. In fact, as soon as the average speed exceeds walking speed, the TTB starts to converge. Once speeds of 10 km/h are achieved, i.e. when people stop walking, the TTBs are grouped together within a relatively small interval.

Graph 2: **Travel time per mobile person and door-to-door speed**



Source: Y. ZAHAVI (1979), The UMOT Project

Thus, with access to car ownership, the time spent on travel decreases then very quickly reaches a threshold beyond which the average duration of transport ceases to fall. *Once a sufficient speed has been achieved (above 10 km/h), average TTB can be considered to be stable at around 1 hour.* By establishing this convergent form, Zahavi is therefore not putting forward the idea that there is a natural chronobiological law which leads people to limit their TTB to one hour. Last, Zahavi attempts to support this hypothesis of constancy by studying a wide range of cities. The diversity with regard to regions, transport systems and cultures, combined with the range of observation dates, means that the hypothesis of the stability of TTB in space and time can be generalized.

Zahavi has studied travel money budgets (TMB) in the same way and has formulated the hypothesis of the double constancy of travel budgets: the constancy of travel money budgets and travel time budgets (TMB and TTB). In Zahavi's Unified Mechanism of Transport (UMOT):

- The average TTB for a city is calculated on the basis of the average *individual daily duration* of travel for the entire *mobile population*.
- The average TMB for a city is calculated on the basis of the average *available household income* that is spent on travel during one year by all the *mobile households* in the city.
- The two average travel budgets are constant over time for each city. The average travel budgets are similar for all cities in the world.

So, according to Zahavi, this constancy is spatially and temporarily transferable.

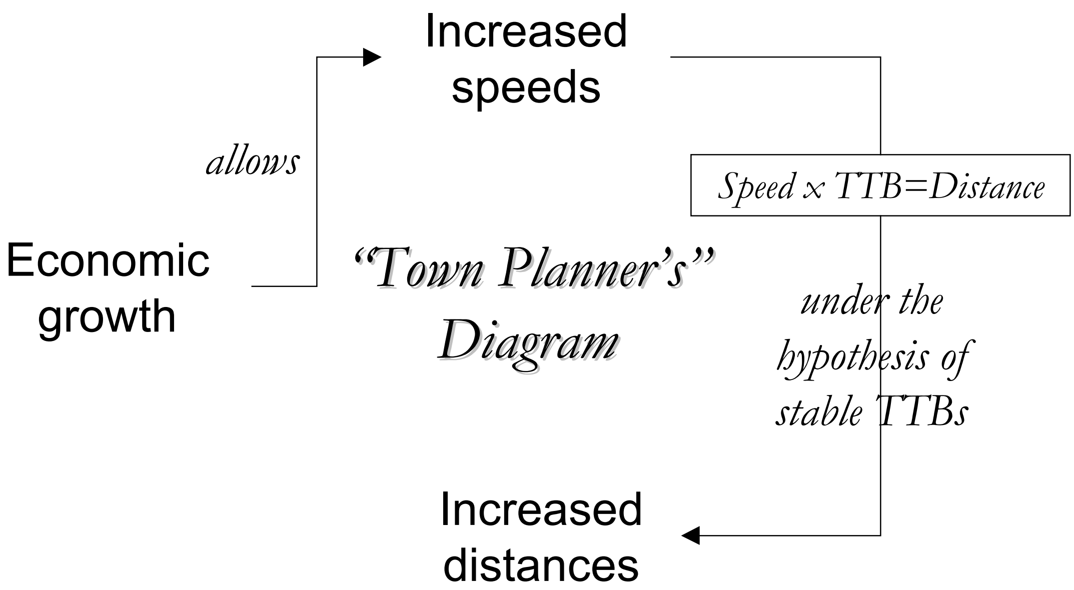
B. Systematic reinvestment of travel time savings

Zahavi describes the mechanism by which an individual acquiring higher speed gains access to new opportunities. A reduction in the temporal cost of transport allows the individual to extend space-time accessibility. The trade-off is therefore between time savings and accessibility improvements. The hypothesis of stable TTB means that the result of this choice favours increases in accessibility. By deciding to reinvest all his/her travel time savings in additional travel, the individual chooses to extend the space-time prism of his activities. This extension results in either performing the same activities more frequently or at more distant locations or adding new activities to his/her timetable. In all these cases, the individual travels a greater daily distance.

Because of the simplicity with which this hypothesis allows us to characterize the mechanisms involved in the economics of personal travel, it reveals an important characteristic of time: it cannot be stored. This is the origin of the reinvestment mechanism and the apparently paradoxical manner in which this scarce resource is managed. Once speed improvements become possible, it is not possible to store the time saved, it must be consumed in one way or another, and for this consumption to provide its beneficiary with the impression that he is making a genuine gain, it is more than likely that it will lead to new trips, for the simple reason that these involve new activities whose marginal utility is greater than those already performed (work, time at home, etc.).

This classical reinvestment mechanism can be summarized in what we shall refer to as the "town planner's diagram" where, with the hypothesis of stable TTB, economic growth leads, as a result of technological progress or an improvement in transport systems for example, to an increase in speeds which relaxes the temporal constraint on travel. Speed thus acts a lever on distance travelled. The correlation observed between TTB stability and increasing speeds and distances is considered as a causality.

Diagram 1: The “town planner’s diagram”



Thus, under Zahavi’s hypothesis, speed and any policy that aims to improve traffic conditions are entirely to blame for the increase in travel and its externalities such as urban sprawl, pollution and energy consumption.

Can this causality, which is defined for an average city which is representative of any city in the world, be applied to explain the urban forms and travel behaviours which are present in the world’s cities?

The UITP database provides rare information on daily travel behaviours in the world’s major cities. The database can be used to analyze information that relates to individual travel behaviours with reference to the characteristics of the cities and their transport system. The collected data relate to the demography, the economy, the urban structure, the transport system, and travel behaviours in the cities[3].

In particular, it allows us to define two clearly distinct urban profiles which can be used to examine the transferability of the reinvestment of time savings. Two types of urban organization with distinct TTB dynamics are apparent. First, an *extensive model* which consists of North American and Oceanian cities which develop through the extension of their consumption of space and time, second an *intensive model*, which consists of European cities and Asian metropolises which manage to maintain relatively stable consumptions of space and time.

II. THE SPACES OF TRAVEL

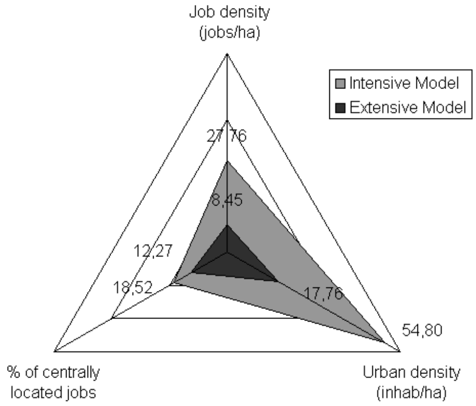
With regard to travel, a city can be described in terms of its urban organization and transport system. The geographical organization of the city provides a framework which influences travel behaviour, both as regards the spatial dispersion of socioeconomic opportunities and as regards travel conditions. The transport system provides a set of travel methods each of which can be defined by monetary and temporal costs and accessibilities.

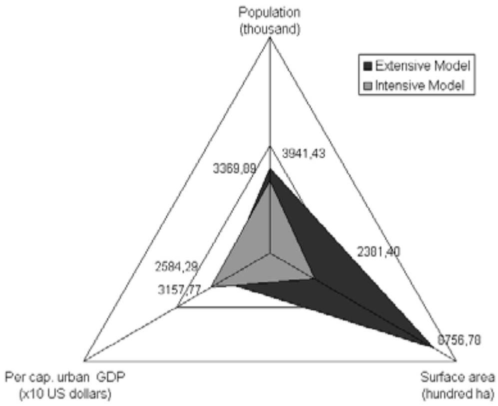
A. Urban structure

Analysis of the “geography” of the cities reveals contrasting urban morphologies. Thus, the extensive model, which applies in the cities of North America and Oceania, is, on average, characterized by lower density and higher surface area and population than the intensive model which applies in Western Europe and Asian metropolises.
The results as regards urban densities reveal a clear contrast: intensive cities are far denser. They manage space more intensively by concentrating jobs and housing. But density also affects the organization of the city’s road system. As has been shown by F. Héran (2003), the travel time between two points in a city depends on the “average detour”, which is the ratio between the distance covered by road and the straight line distance. If we compare the average detour for different urban morphologies, we can also see a contrast between “European” cities and “American” cities. The regular grid pattern which is typical of American cities and a few districts of European cities results in an average detour of approximately 30%. If we look at a city centre network which is irregular but dense, as is typical in many European cities, the average detour is approximately 15 to 25%. We should note that the form of the road network depends very greatly on the dominant transport mode. There has been no hesitation in modern cities to lengthen the average detour as a result of the speed of cars, as the increased speed more than makes up for the greater distance.

***Graph 3:* General indicators depending on the type of urban organization**

***Graph 4:* Urban density indicators depending on the type of urban organization**



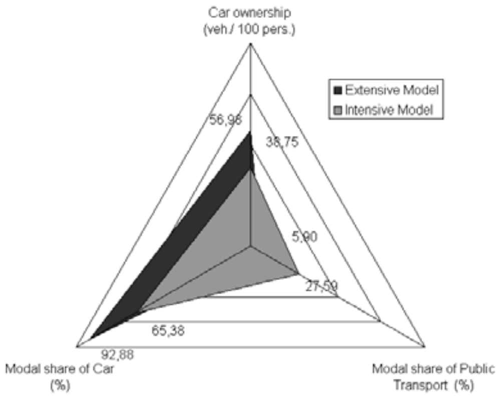


Thus, in the case of an apparently equivalent level of economic activity, extensive cities are built with few spatial constraints. The relative wealth of cities in spatial terms is certainly partly explained by geographical (topographic) constraints acting on the city, but the history of the transport modes which permitted its development must also be considered. Furthermore, the different urban morphologies and contrasting dispersion of socioeconomic opportunities leads one to think that distinct travel needs will result from the different types of organization. Consequently, the transport systems which meet these needs are likely to be oriented differently.

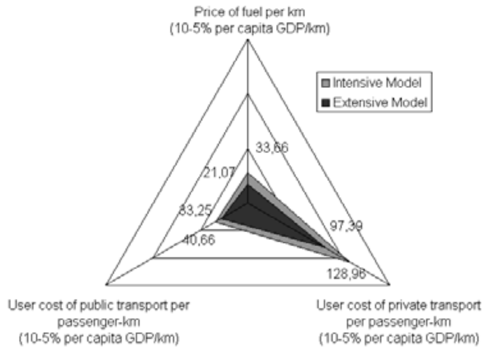
B. The transport systems

The extensive model is very strongly marked by dependency on the car. In these cities, the car has a market share of 92.88%, leaving public transport with only a very small role (5.9%) and making the use of other non-motorized modes exceptional (less than 2%). Public transport and the use of non-motorized modes tend to be preserved in intensive cities and together account for one third of trips. Coproduction between the urban structure and the transport system therefore seems to indicate that urban density provides a means of safeguarding public transport.

***Graph 5:* Use of motorized transport modes according to the type of urban organization**



***Graph 6:* User cost of motorized transport modes according to the type of urban organization**



The individual choices which underlie modal split are partly explained by the relative cost of transport; the cost of car travel is lower in extensive cities than in intensive cities.

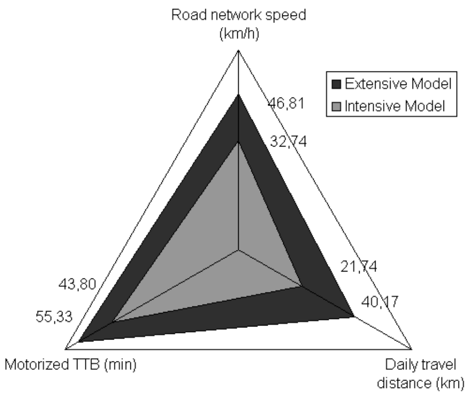
In the short term, choice of the car is rational in the extensive model because of the urban structure and the relative costs of the different modes. However, in the long term, this choice can be questioned. Co-production between the city and transport implies a relationship of mutual interaction (Wiel, 1999).

III. TRAVEL TIMES

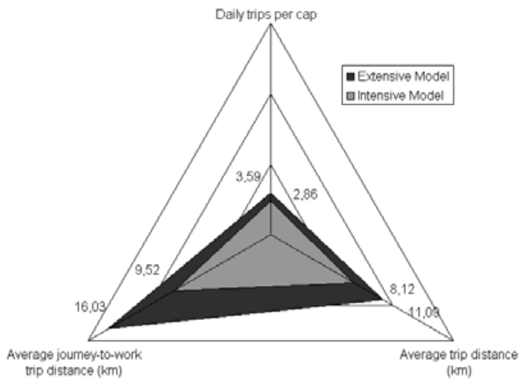
A. Contrasting travel behaviours

This contrast between different models of urban organization is accentuated by the observed differences in travel behaviour. In spite of higher speeds, TTBs are higher in the extensive model (Figure 5). In these cities, it is as though increased incomes provide higher speeds and require greater distances. The orientation of the transport system towards the car, which is made possible by higher income, does not seem to save time. In spite of the relative efficiency of the extensive model in terms of speed, these cities experience spatial and temporal expansion. The distances travelled exceed what can be achieved with a TTB of one hour. This leads us to re-examine the causal link that has been established between the distance, time and speed, which, under Zahavi's conjecture, involved a systematic reinvestment of time savings.

***Graph 7:* Travel indicators according to the model of urban organization**



***Graph 8:* Travel indicators according to the model of urban organization**



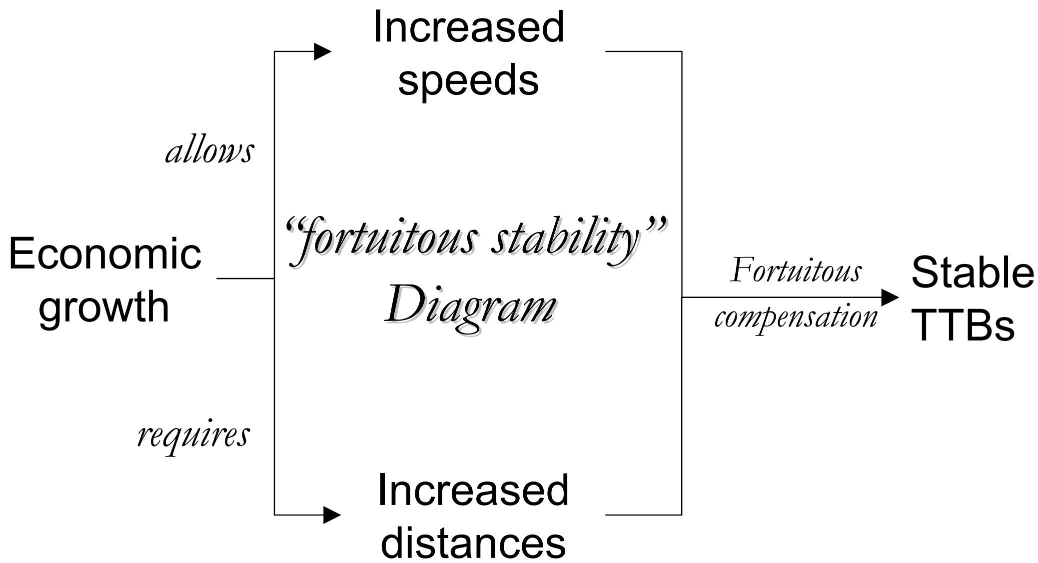
B. Towards a new causality

These findings indicate that the tendency for the zone of activities to be extended is greater than under the hypothesis of constant TTB.

It is as though the desire or the need for space has increased and encourages individuals to extend their spatial field beyond what is permitted by speed gains. While the interpretation of the link between speed, distance and TTB which has prevailed until now makes speed responsible for increases in the spatial range of trips with an assumption that TTB remains constant, from these results it would appear that spatial extension has broken the TTB barrier.

Zahavi's conjecture states that a stable TTB is maintained as the result of complete reinvestment of the time savings "caused" by speed. But the "extensive" model seems to indicate the presence of "fortuitous stability" (Diagram 2). Economic growth requires more travel and as a result of technological progress increases speed. The two effects can compensate for each other and result in stable TTBs being maintained. Or perhaps, in cities with the extensive model, speed gains are not sufficient and in order to meet the travel needs generated by economic growth, TTBs must rise.

Diagram 2: **fortuitous stability**



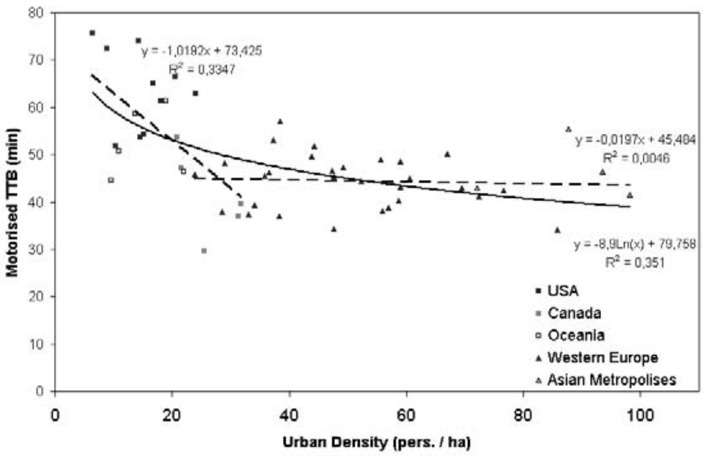
We can envisage several TTB stabilization mechanisms. Observations of TTB stability may be simply the result of statistical chance. Other disciplines (sociobiology, chronobiology) have attempted to find behavioural invariants which are specific to mankind, but more frequently the stability is considered to be structural and therefore the result of compensation mechanisms within the population. Last, combining these approaches, Hägerstrand (1973) suggests that a worker's working day can be divided into nine hours of sleep and personal care, one hour of eating (excluding cooking), eight hours of working and 1.5-2 hours of shopping and other service activities. The remaining 4-4.5 hours are left for travel and leisure. It is, then, not surprising that the average time devoted to travelling is about 1 hours.

The extensive city model not only invalidates the transferability of Zahavi's conjecture to any level less aggregated than the whole world, it also casts doubt on the causal link between speeds, TTB and travel distances. *Although TTBs lose their role of maintaining travel levels constant, speeds retain their ability to generate travel. Increased levels of travel, which according to Zahavi's conjecture, could simply be a linear projection of speed gains could, in the case of the extensive model, be exponential.*

C. Levers that can affect travel behaviour

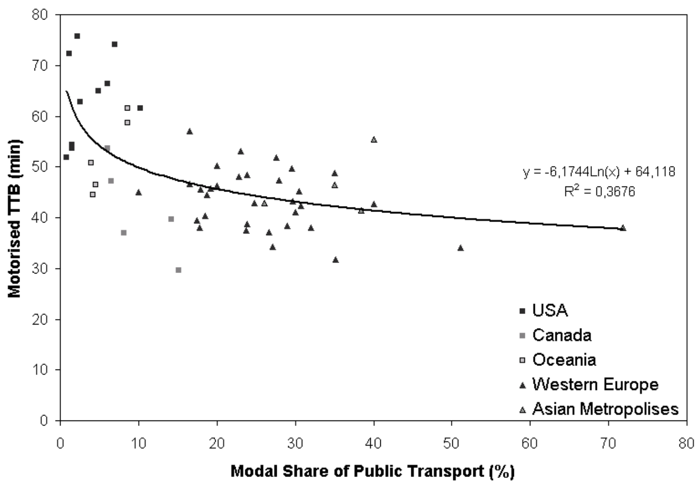
The analysis of travel times in cities also reveals a number of links between TTB and available variables. Thus, there is a decreasing relationship between TTBs and the dispersion of socio-economic opportunities as measured by urban density (Graph 3), job density and the percentage of centrally located jobs. This replicates the findings of Newman and Kenworthy (1989) and Kenworthy and Laube (1999). This relationship would therefore seem to indicate that extensive cities pay for their spatial extension and dispersion by an increase in travel times.

***Graph 9*: Motorized TTB per person (in minutes) and urban density (in persons per hectare) in Western Europe, North America, Oceania and Asian metropolises.**



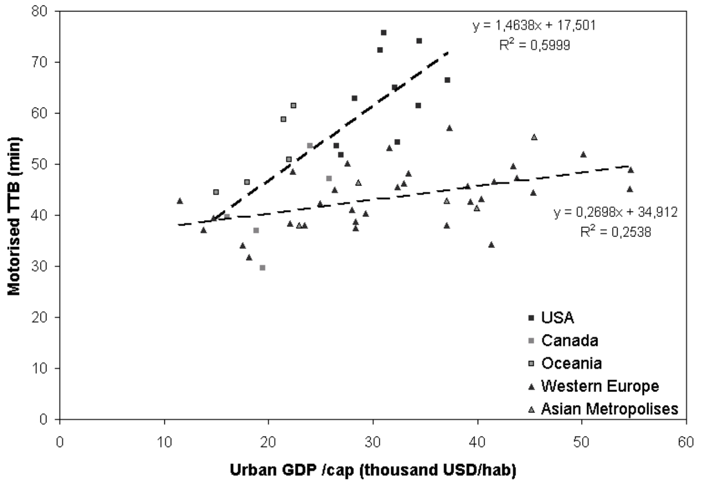
TTBs also seem to increase with daily travel distances, speeds on the road network and car ownership rates. In addition, indicators that describe provision of public transport services lower TTBs (Graph 11).

***Graph 10*: Motorized TTBs per person (in minutes) and modal share of public transport (%) in Western Europe, North America, Oceania and Asian metropolises.**



Last, the TTBs of each urban profile in some cases exhibits distinct dynamics. Thus, the per capita GDP only affects the TTB in the extensive model.

***Graph 11*: Motorized TTBs per person (in minutes) and per capita urban GDP (in thousand US dollars) in Western Europe, North America, Oceania and Asian metropolises.**



These bivariant analyses show that there are a certain number of levers which can potentially affect urban TTBs. However, the majority of these relationships have only been validated at global level, and we have seen that the TTBs of the two urban organization profiles may exhibit different dynamics. Consequently, the global relationships are only valid if we hypothesize the continuity of profiles. The relationships we have identified highlight the implications of the convergence of one model towards the other. While it is unlikely that a European city will turn into a city of the extensive type, a shift towards one or other of the urban models is much more likely when one considers a growing developing city.

Multivariate analyses

Multidimensional analysis is required to identify the levers that can play a role in the management of urban space and time. To begin with, to perform multiple regression, the most relevant variables with the highest correlation with TTB were selected within each subgroup of explanatory variables: urban geographic variables, variables relating to travel and the cost of travel and variables relating to the supply of public transport services and investment levels. *Table 1* sets out the results of the multiple regression for TTBs. Once again, we find the variables that relate to the three dimensions mentioned above. The standardized coefficients of the impact of the variable on TTBs and the orders of magnitude of the different coefficients allow us to compare the scales of the effects. In general, the coefficients are significant at the 10% confidence level. Thus, for all cities car ownership has a positive effect on TTBs and PT investment appears to reduce (or contain) TTBs. The extensive model is marked out by positive effects of the distance covered and the ratio between the costs of PT and car use and negative effects of PT market share. However, our estimation provides some disconcerting results. For example, the signs of the coefficients associated with some variables do not agree with the results of the previous analysis. This applies, for example, to speed which has a negative coefficient and therefore reduces TTBs. Another case is PT supply measured by PT seat-km per person which has a positive coefficient.

The causalities which are assumed by the structure of this model are very much open to question. For example, the regression may take in situations where PT investment is a reaction aimed at improving difficult travel conditions. Furthermore, we have strong grounds for suspecting that the explanatory variables in the model may be endogenous and multicolinear – travel time, distance and speed are strongly related, but the causality linking them is not univalent. These two effects are particularly likely in view of the fact that our data consists of combined series. The very low stability of the coefficients when the model specification is slightly altered is an indicator of this situation.

***Table 1*: Multiple regression**

Variable	Estimated coefficients	Standard deviation	P-level	Standardized estimators
Constant	58.01	6.67	<.0001	0
Effects that are specific to extensive profile				
Journey to work distance	3.10	0.55	<.0001	2.29
PT market share	-0.84	0.39	0.0411	-0.31
Ratio of user costs (PT/Private)	161.12	74.20	0.0405	0.32
Speed on roads	-0.79	0.29	0.0125	-1.39
Effects for all profiles				
Speed on road network	-0.79	0.18	0.0002	-0.51
Public transport seat-km per person	0.002	0.0005	<.0001	0.44
Car ownership rate	0.02	0.01	0.0361	0.22
% of urban GDP spent on PT operating costs	-6.63	1.62	0.0004	-0.30
R^2	*0.927*			

Principal Component Analysis

Ultimately, the classical and convenient MCO method does not seem to be the most appropriate for identifying the levers of action in the case of our sample. We have therefore conducted a principal component analysis on the most relevant variables (Table 2). The first principal component (F1) reveals the influence of urban organization. This initial effect (which explains 53% of TTB variance) links TTBs positively with distances covered, number of trips, level of car ownership, speed on the road network and the extensive urban model. Here, there is a negative link between TTB and urban density, the market share of public transport, the ratio between PT speed and car speeds. The second principal component (F2) (which explains 22% of the variance of TTBs) reveals a positive wealth effect. The ratio between speeds appears to be in this case positively linked to the TTB. However, the second effect is counteracted by the effect of the first component. Speed therefore seems to have a positive effect on TTB, and PT supply and use reduces TTBs. Ultimately, the variables which define and characterize urban organizations explain more than 80% of the TTB. If we look at the correlation circle for the first two components (F1 and F2), which explain 65% of the total variance, we can see a group of variables which are grouped together on the right-hand side, which shows there is correlation between them. These variables relate to the indicators of extensive travel behaviour (high levels of speed, car ownership, distance covered, number of trips and TTBs). In diametric opposition to these, we can see the variables which are negatively correlated with these, which include the indicators that relate to PT and urban density.

***Table 2:* Eigenvalues and the variance which is explained by each principal component**

	F1	F2	F3	F4	F5	F6	F7	F8	F9
Eigenvalue	6.892	2.223	1.148	1.079	0.688	0.550	0.410	0.296	0.245
% variance	49.226	15.881	8.200	7.708	4.912	3.927	2.932	2.114	1.749
Cumulative %	49.226	65.108	73.308	81.016	85.928	89.855	92.787	94.901	96.650

The PCA results presented here only take account of principal components which explain more than 5% of the variance.

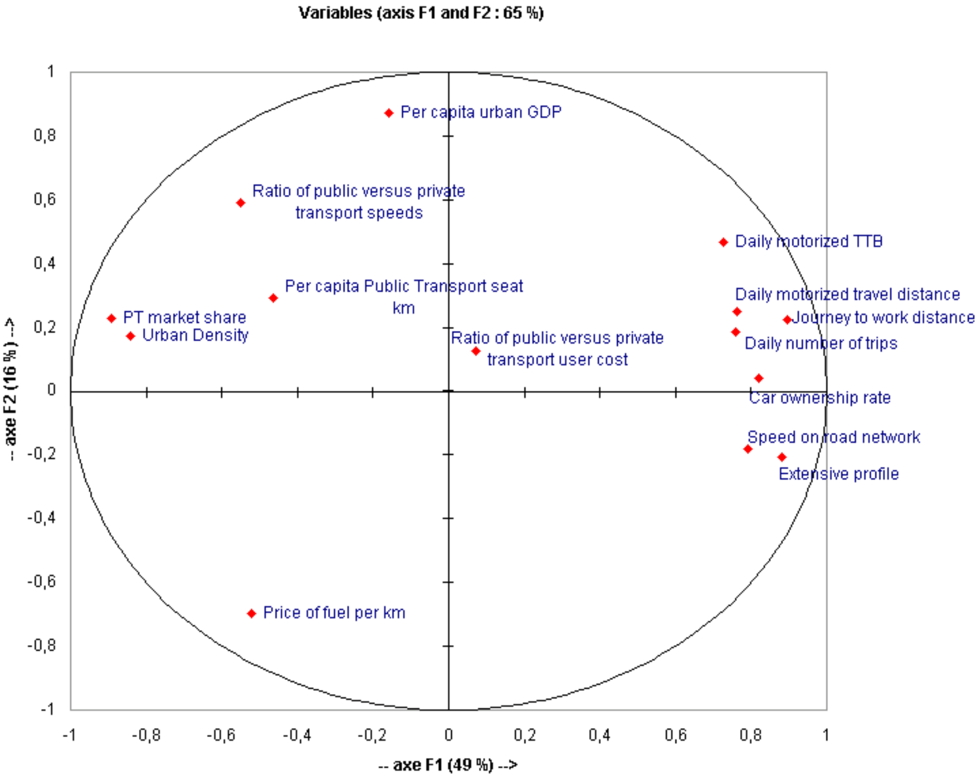
***Table 3:* Eigenvectors**

	F1	F2	F3	F4	F5
Urban density	-0.320	0.116	-0.119	-0.094	-0.350
Per capita urban GDP	-0.061	0.585	-0.107	-0.171	0.310
Car ownership rate	0.313	0.026	-0.175	-0.287	0.039
Speed on road network	0.302	-0.122	-0.103	0.372	0.237
Per capita public transport seat km	-0.177	0.197	0.113	0.644	0.461
Daily number of trips	0.289	0.124	0.183	-0.245	0.239
PT market share	-0.340	0.153	-0.218	0.083	-0.090
Journey to work distance	0.291	0.166	-0.067	0.378	-0.398
Price of fuel per km	-0.199	-0.468	0.166	0.185	-0.169
Ratio of public versus private transport speeds	-0.209	0.396	0.183	0.148	-0.355
Ratio of public versus private transport user costs	0.027	0.084	0.877	-0.088	-0.023
Daily motorized travel distance	0.341	0.151	-0.050	0.208	-0.155
Daily motorized TTB	0.277	0.312	0.033	0.028	-0.286
Extensive profile	0.336	-0.138	0.026	0.094	-0.163

***Table 4:* Contribution of each principal component to the variance of each observed variable (%)**

	F1	F2	F3	F4	F5
Urban density	0.706	0.030	0.016	0.010	0.084
Per capita urban GDP	0.025	0.762	0.013	0.032	0.066
Car ownership rate	0.674	0.001	0.035	0.089	0.001
Speed on road network	0.629	0.033	0.012	0.149	0.039
Per capita public transport seat km	0.217	0.086	0.015	0.448	0.146
Daily number of trips	0.575	0.034	0.038	0.065	0.039
PT market share	0.796	0.052	0.055	0.007	0.006
Journey to work distance	0.584	0.062	0.005	0.154	0.109
Price of fuel per km	0.273	0.488	0.032	0.037	0.020
Ratio of public versus private transport speeds	0.302	0.349	0.039	0.024	0.087
Ratio of public versus private transport user costs	0.005	0.016	0.883	0.008	0.000
Daily motorized travel distance	0.801	0.050	0.003	0.047	0.016
Daily motorized TTB	0.529	0.217	0.001	0.001	0.056
Extensive profile	0.777	0.042	0.001	0.009	0.018

***Graph 11*: Correlation circle**



CONCLUSION

The TTB stability that was hypothesized in 1980 by Yacov Zahavi is a simplification of the convergent relationship between TTB and speed. Convergent TTBs can achieve stability when a large number of cities around the world are considered and when average speed exceeds walking speed. This assumption of stability is useful for transport economics because it provides us with a simple mechanism that explains the trade-off between time and space faced by individuals. Under the hypothesis of TTB stability travel time savings are systematically reinvested, so travel distances increase.

However, the breakdown we have performed using quantitative analyses (Regression Analysis and Principal Component Analysis) suggests that two distinct types of urban structure exist. First, there is an extensive urban model (North American and Oceanian cities) characterised by high consumption of temporal and spatial resources, and a car-based transport system. Second, there is an intensive urban model (Western European cities and Asian metropolises) with high urban densities, low temporal and spatial consumption and a greater role for public transport. These two urban organizations exhibit distinct TTB dynamics. The regression analyses confirm that such classical variables as urban density and urban GDP have both general and separate effects on TTB. The main question is therefore whether one type of city can change into the other type.

Finally the link between TTB and speed seems somewhat paradoxical. On the one hand, speed appears to be responsible for the explosion in distances, and reducing speeds would therefore appear to be a way of limiting the spatial expansion of cities. On the other hand, speed fails to reduce TTBs, rather seeming to increase them. The new accessibilities seem to compensate more and more effectively for the disutility of travel time. Thus, a speed reduction policy appears unrealistic and inefficient if TTBs are only flexible upwards. The reinvestment of travel time-savings partly explains travel choices, but in order to understand these fully we must consider the large number of dimensions that interact to produce the dynamics of cities.

NOTES

[1] In 1972, Szalai noted that similar amounts of time were allocated to transport in different countries. As this similarity was still observed in spite of differences in travel speed, Szalai assumed that time savings were reinvested. This observation, in the context of a broader analysis of the uses of time, prompted Zahavi to focus on the mechanisms involved in the allocation of time to travel.
[2] Athens, Baltimore, Baton Rouge, Bombay, Brisbane, Chicago, Columbia, Copenhagen, Kansas City, Kingston, Knoxville, London, Meridian, Pulaski, Saint Louis, Tel-Aviv, Tucson, West Midlands.
[3] 175 indicators, relating to 1995, are available for 100 cities in the world. All the continents are represented, as are the different sizes of city from Graz (240,000 inhabitants) to the Metropolitan District of Tokyo (32.3 million inhabitants). Our analysis has concentrated on the 60 cities located in developed countries.

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